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An Optimal Rice Policy for Sierra Leone

Balancing Consumer and Producer Welfare

Errol George Graham
Hardwick Tchale
Mamadou Ndione

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Abstract

Rice is a staple food in the West African nation of Sierra Leone with little difference in consumption between poor and wealthy households. Rice production is also an important source of livelihood with half of all households, three-quarters of rural households and about two-thirds of poor households grow rice. The final price of rice in the domestic market is an important policy issue. The policy challenge is complicated by the fact that poor households, which earn the bulk of their income from rice production, also purchase rice when own production is inadequate. Under the broad assumption that money income is a reasonable measure of well-being, this paper develops a simple model of the Sierra Leone rice sector and applies procedures to determine key outcomes in terms of domestic production, imports, and exports under conditions that maximize consumer's and producer's surplus. The paper finds that the rice sector is operating at a suboptimal level. In addition, simulations suggest that an optimal policy path to balance consumer and producer welfare and meet the higher societal objective of creating jobs requires a moderate level of tariff on imported rice, combined with structural policies to improve the productivity of the sector.

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Errol George Graham, Hardwick Tchale and Mamadou Ndione[1]

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[1] Errol George Graham, Hardwick Tchale and Mamadou Ndione are respectively Lead Economist, Senior Agriculture Economist and Senior Economist at the World Bank. Errol George Graham is the corresponding author and can be reached at egraham@worldbank.org. The findings and conclusions of this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank, its Executive Directors, or the countries they represent.

I. Introduction and Background

Sierra Leone is one of the poorest countries in Africa with 7.6 million people and a GDP per capita of US$439 (World Bank, 2018). The country shares a northeast border with Guinea, a southeast border with Liberia and is open to the Atlantic on the west and southwest. Sierra Leone has a highly advantageous geography and significant renewable natural resource endowments in land, forest and fisheries. Almost 75 percent of the total land area of about 72,300 km^2 is arable. Abundant rainfall (3,000 -5,000 mm per year on the coast and 2,000 – 2,500 mm inland), naturally fertile soils, sunlight and river basins make the country suitable for a wide variety of food and cash crops (World Bank, 2018). The country is also well-endowed with mineral resources. Extensive alluvial and kimberlitic diamond deposits as well as bauxite, rutile, and gold have been discovered in the east and south of the country and gold, iron ore and more recently bauxite are being mined in the north. Despite its substantial natural resources, more than half of Sierra Leone's population is poor and more than three-quarters of the poor live in rural areas and most are engaged in agriculture.

Rice is a staple in Sierra Leone with an annual per capita consumption of 104kg[2]—among the highest in the Sub-Saharan Africa region. Per capita consumption was even higher in the 1970s reaching 127kg. However, domestic yields are low (averaging less than 2 metric tons per hectare per year) and overall production, averaging 620,000 tons per year in the last 10 years is inadequate to meet consumption estimated at about 1,000,000 tons of milled rice and an annual average of 300,000 metric tons of rice are imported. Most of the imported rice is consumed in Freetown, the capital city and the provincial towns, but a small proportion is consumed in the rural areas, mainly in July and August when the stock of locally produced rice is at the lowest.

Sierra Leone has a natural comparative advantage in the production of rice and up until the mid-1950s it had been a net exporter of rice (Kargbo, 1979). Sierra Leone has imported more than US$100 million worth of rice per year since 2012, an amount equivalent to one-fifth of its international foreign reserves. According to Fornah, Spencer, and Wilson (2014) about 187,000Mt of paddy rice are marketable surplus, representing 10-15 percent of domestic production. A substantial proportion of this surplus goes through the traditional value chain, which accounts for 85-90 percent of the marketable surplus. The traditional rice value chain involves mostly smallholders who supply relatively poor-quality rice (with over 35 percent broken grains) to both rural and urban consumers, but only a small proportion reaches Freetown. The modern rice value chain involves a mix of both smallholder and large-scale producers who market rice through institutional buyers. The quality of the rice in the modern value chain is of similar quality to imported rice.

Increasing the share of the modern value chain could create more and better jobs, especially for youth and women in rural areas. Further development of the modern value chain (and to some extent, the traditional value chain) is constrained by low yields and competition from subsidized rice imports. Currently, the tariff (15 percent) on imported rice is waived. Further, in some instances, the overvalued exchange rate has held to keep the imported rice price low. For example, in 2017 the IMF estimated that the currency was overvalued by 15-17 percent.[3]

[2] Spencer, Deen and Wilson, 2009. The economics of rice production in Sierra Leone.
[3] IMF Country Report No. 17/154, June 2017.

Rice is a strategic commodity for food security in West Africa. Total consumption in the region is expected to reach 24 million metric tons by 2025. Dependency on imported rice exposes the region, and the heavily dependent countries to external shocks from volatility in the global market.

The price of rice, and practically all staple food commodities in Sub-Saharan Africa, is therefore an important issue which has challenged policy makers. Policy makers face a dilemma because a significant proportion of poor households are net food buyers. On the one hand, as rice producers, they earn the bulk of their income from rice production, and on the other hand, they also purchase rice when their own production is inadequate. Thus, the impact of rice policy on the level of producer and consumer prices poses a significant public policy dilemma. In this paper, we try to address this issue focusing on Sierra Leone where this policy dilemma is most significant, given the country's heavy dependence on rice. We assume that money income is a reasonable measure of well-being, and we thus develop a simple model of the Sierra Leone rice sector and apply procedures to determine key outcomes in terms of domestic production, imports and exports under conditions that maximize consumer's and producer's surplus which lead to the most efficient social outcome.

The remainder of the paper is organized as follows: Section II provides a brief overview of the theoretical framework on demand and supply and the concepts of consumer's and producer's surplus as a measure of welfare for the consumer and the producer, respectively. Section III reviews the empirical literature. Section IV describes the structure of the rice sector and details the specification of the models as well as discusses the available data, and the sector policies of the government, including the broad objectives. Section V of the paper discusses the technical and policy simulations and the results; and Section VI concludes with some policy implications.

II. Theoretical Overview

a. Theory of demand and the concept of consumer surplus

The theory of demand is rooted in the theory of consumer behavior, involving utility maximization. The general idea is that the typical consumer chooses a vector of goods (x), which have prices (p) to maximize her utility (*u*), subject to a budget constraint or total wealth (w). The choice calculus may be represented as:

Max *u* (x)

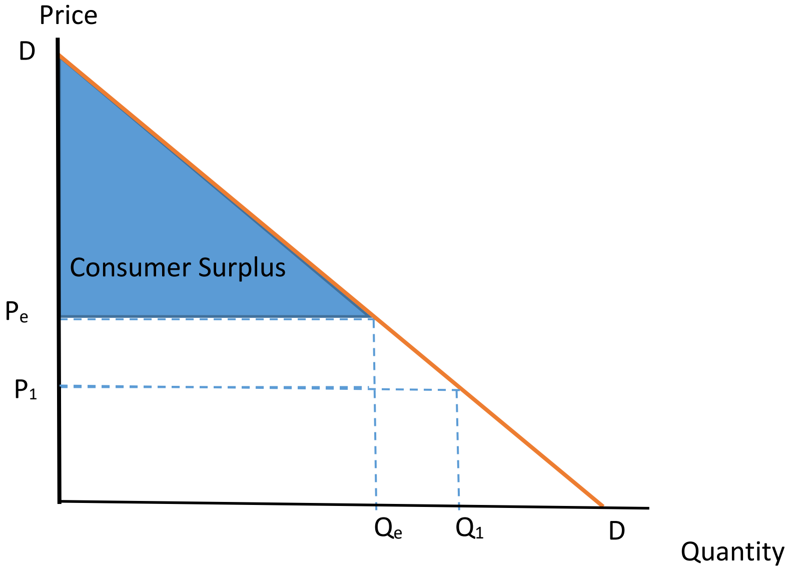
Subject to $p * x \leq w$

It has been shown, for example by Levin and Milgrom (2004) that if *u* is continuous and p is greater than zero, the consumer choice problem can be solved and represents the Marshallian demand. Aggregating over the individual demand, as they strive to maximize their utility, gives the industry demand for a commodity.

Demand elasticities are analogous to supply elasticities and are a ratio of the relative changes in income or price to the corresponding ratio of relative changes in quantity. Although in theory, there is a quantity response to both income and price, in practice, directly estimated demand curves do not separate out the two responses. It has been argued (Bivings and Gotsch, 1990 for example) that unless the expenditures on the good, and the variations in question are large relative to the consumer's income, the error in using an ordinary demand curve to calculate a price elasticity of demand will be small.

Figure 1 below depicts the Marshallian concept of consumer's surplus which is the monetary gain to consumers from being able to purchase a product for a price that is less than the highest price that they would be willing to pay. The demand function DD represents the various quantities on the horizontal axis that consumers are willing to purchase at different prices on the vertical axis. In a competitive market, producers must sell all units of the commodity at the same price, that is the equilibrium price (P_e). The shaded area between the equilibrium price and the demand curve bounded by where the demand curve intersects with the vertical price line represents the consumer surplus.

Figure 1. Consumer Surplus



b. Theory of supply and the concept of producer surplus

The theory of supply falls under the general umbrella of production economics. Microeconomic theory suggests that if factor prices are known and assuming profit maximizing behavior, a firm's supply curve can be derived from its production function. The production function portrays an input-output relationship and can be written symbolically as:

$Y = f(X_1, X_2, X_3, \ldots\ldots\ldots\ldots, X_n)$

Where Y is output and $X_1 \ldots\ldots\ldots X_n$ are the different inputs that are employed in the production of the output Y. The functional symbol "f" indicates the form of the relationship that transforms inputs into output. The above symbolization of the general production function does not indicate which inputs are fixed and which are variable. Land is usually considered to be a fixed input, while seed, fertilizer and other intermediate inputs are considered to be variable inputs that are applied to a fixed input to produce a certain amount of output. The production function with fixed input can be expressed as:

$Y = f(X_1, X_2, X_3, \ldots\ldots\ldots\ldots, X_{n-1} \mid X_n)$

Where Y is the output, $X_1, X_2, X_3, \ldots\ldots\ldots\ldots, X_{n-1}$ are the variable inputs and X_n is the fixed input.

The production function assumes a technological set, which embodies all the technical information about the feasible combinations of inputs, both fixed and variable, required to produce the output at a point in time. Innovations may result in new and more efficient combinations of inputs—technological progress. The effect of technological progress is an upward shift of the production function. This makes it possible for the same output to be produced with fewer factor inputs, or for more outputs to be produced with the same inputs.

The supply curve for an individual firm in perfect competition would be the firm's marginal cost curve above the average cost in the short run. The firm's long-run supply curve would be that portion of its long-run marginal cost curve for which marginal cost exceeds average cost. In the short-run, the farmer will produce if she is able to cover her variable costs. The horizontal summation of the individual firm's supply function gives the industry's supply function.

The main factors affecting the supply of an agricultural commodity include: (i) the price of the commodity; (ii) the price of other commodities; (iii) prices of inputs or factors of production; (iv) the level of technology; (v) the level of fixed factors; (vi) risk; and (vii) weather factors. This relationship may be expressed algebraically as:

$Q_s = \int (X_1, X_2\ X_3\ldots., X_n)$

Where Q is the quantity of output

X_1 to X_n are quantities of variable and fix factors of production (labor, land, capital, etc.).

From the equation above, it follows that, holding all other factors constant, the quantity of commodity supplied varies with the price of the commodity. This is termed the supply response and the parameter that captures the sum of the changes in supply in response to a change in the price of the output is referred to as the total price elasticity of supply. Denoting this parameter by E_s the equation for the elasticity of supply is given as:

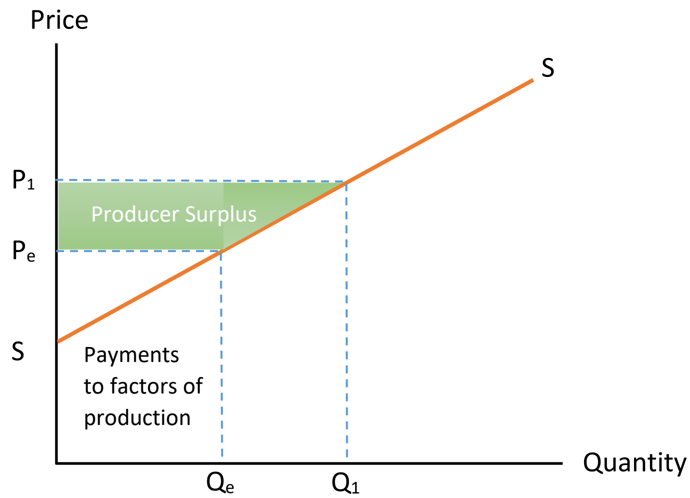
E_s = relative change in quantity supplied/ corresponding relative change in output price

Producer's surplus is a measure of producers' welfare. The term was first proposed by Arsène Jules Étienne Juvenel Dupuit (1804-1866), an Italian economist, but was brought into mainstream economics language by Alfred Marshall (1842-1924). As Marshall (1890) argues:

"*When different producers have different advantages for producing a thing, its price must be sufficient to cover the expenses of production of those producers who have no special and exceptional facilities; for if not they will withhold or diminish their production, and the scarcity of the amount supplied, relatively to the demand, will raise the price. When the market is in equilibrium, and the thing is being sold at a price which covers these expenses, there remains a surplus beyond their expenses for those who have the assistance of any exceptional advantages. If these advantages arise from the command over free gifts of nature, the surplus is called a producer's surplus or producer's rent.*"

Figure 2 below shows graphically the concept of producer's surplus in the Marshallian context. Under the assumption that the area under the curve is made up entirely of variable costs, this amount represents payments to factors of production. Since in a competitive market, all producers receive the same price, firms other than the marginal firm will receive a rent over and above the returns needed to cover the payments to factors of production. The sum of the rent received by all firms beyond the margin is called the *producer's surplus*, depicted by the shaded area in Figure 2. A rise in the price of the product above P_1 will result in an increase in the level of producer surplus and a fall in the price below P_1 will result a reduction in the level of producer surplus. As prices rise and producer's surplus is increased, the welfare of producers is improved, but the welfare of consumers is diminished.

Figure 2. Producer's Surplus



III. Empirical Literature

Since its proposition by Dupuit in 1844 and introduction into mainstream economics language by Alfred Marshall, the concept of consumer's surplus has been controversial. Some of the more prominent early critics included Pareto (1892); Patten (1893); Hicks (1939); Samuelson (1942); and Friedman (1949). See for example, Dooley (1983) for a summary of the criticisms and the responses from Marshall and his supporters. Despite the criticisms, the Marshallian concept of consumer's surplus has been a widely used tool for welfare analysis. This may in part be due to the acceptance of Harberger's encouragement of the use of consumer's surplus to measure both individual and social welfare.[4] Harberger (1971) pleaded that his three basic postulates be accepted as providing a conventional framework for applied welfare economics. These postulates are: (a) the competitive demand price for a given unit measures the value of that unit to the demander; (b) the competitive supply price for a given unit measures the value of that unit to the supplier; and (c) when evaluating the net benefits or costs of a given action (project, program, or policy), the costs and benefits accruing to each member of the relevant group should normally be added without regard to the individual(s) to whom they accrue.

Harberger also suggests that the skepticism in the use of consumer's surplus as a measure of welfare rests on one or more of the following grounds: (i) consumer's surplus analysis is valid only when the marginal utility of real income is constant; (ii) consumer's surplus analysis does not take account of changes in income distribution caused by the action(s) being analyzed; (iii) consumer's surplus analysis is partial-equilibrium in nature, and does not take account of the general-equilibrium consequences of the actions

[4] Harberger, Arnold C. 1971. "Three Basic Postulates for Applied Welfare Economics," Journal of Economic Literature, Vol. 9, No.3 pp. 785-97.

whose effects are being studied; (iv) consumer's surplus analysis, though valid for small changes is not so for large changes; and (v) the concept of consumer's surplus has been rendered obsolete by revealed-preference analysis. In his open letter to the economist profession, Harberger systematically responded to the five objections against the use of consumer's surplus as a measure of welfare (See Harberger, 1971).

a. Supply response in the rice sector

From economic theory, own-price supply response of agricultural commodities is normally positive. However, the transmission of price signals to farmers' production decisions tends to be different depending on whether or not the commodity in question is a staple or not, and more importantly, whether there are well-functioning input, output, financial, and other factor markets (Haile, Brockhaus and Kalkuhl, 2016).[5] In the case of rice, which is considered a major staple in most countries, more-so in most countries in Sub-Saharan Africa, the supply response has been estimated to be rather muted or sluggish. This is because first, staple commodities such as rice largely define the livelihood of most smallholders that grow it. And because most markets either do not exist or exhibit significant degree of failure, farmers are unlikely in the short run, to change their production decisions in response to market signals. Second, most farmers tend to be net food buyers, and hence risk-aversion tends to override any rational response to price signals, which affect them both as consumers and producers. Third, both output and yield response tend to be affected by many non-price structural and institutional factors, such as technology, government's protectionist policies (e.g. import restrictions or tariffs etc.). In Nigeria, for example, Akanni and Okeowo (2011) indicate that the food supply response has been limited by structural and institutional constraints that have persisted despite market reforms implemented over several decades and suggest that investments (both public and private) in irrigation could help to raise output. In Sierra Leone, Conteh et al. (2014) found that both the short-run and long-run price response was inelastic mainly due to both structural and institutional factors that affected farmers' perception of market signals. It is clear that in the case of staple commodities such as rice, which tend to dominate public policy in terms of food security, the optimal way to guide policy decisions and interventions is to assess the impact of any interventions on both producers and consumers. In Sierra Leone and many other countries that are net rice importers, governments need to understand the impact of policy interventions on both producers and consumers.

b. Impact of tariffs and subsidies on supply and demand

Import tariffs are typically enacted to protect a country's domestic producers, but economists have long debated how much of this protection comes at the expense of domestic consumers through higher prices. It is difficult to measure the net effect of tariff increase. Obviously, the way in which import demand and domestic supply respond to changes in tariffs will depend on how producers and consumers react to price changes, the share of imports in total consumption, and the substitutability of imports for domestic products. The reaction to tariff change differs from country to country as well as from commodity to commodity. Probably the most common argument for tariff imposition is the infant industry argument (IIA[6]), was initially devised by Alexander Hamilton (1791) and Friedrich List (1841). It argues that new industries, particularly in low income countries, need to be sheltered from foreign competition. They assume that costs decline with growth and that some industries must reach a minimum size before they are able to compete with well-established foreign industries. Thus, tariffs can protect the domestic market

[5] Haile, M.G., Brockhaus, J., and Kalkuhl, M. 2016. Short-term acreage forecasting and supply elasticities for staple food commodities in major producing countries. Agricultural and Food Economics, December 2016, 4:17.

[6] IIA is recognized by the WTO as a legitimate reason for restricting trade.

until the industry becomes internationally competitive. In short, the infant-industry argument is based principally on the idea that there are economies of large-scale production in many industries and that developing countries have difficulty in establishing such industries. Tariffs are also proposed to maintain domestic employment. The most common counter argument is the comparative-advantage theory (David Ricardo, 1817 and Shiells *et al*, 1988),[7] which argues that the industry in need of such protection will likely not survive and that the resources allocated to that sector need to be transferred to occupations that have greater comparative advantage.

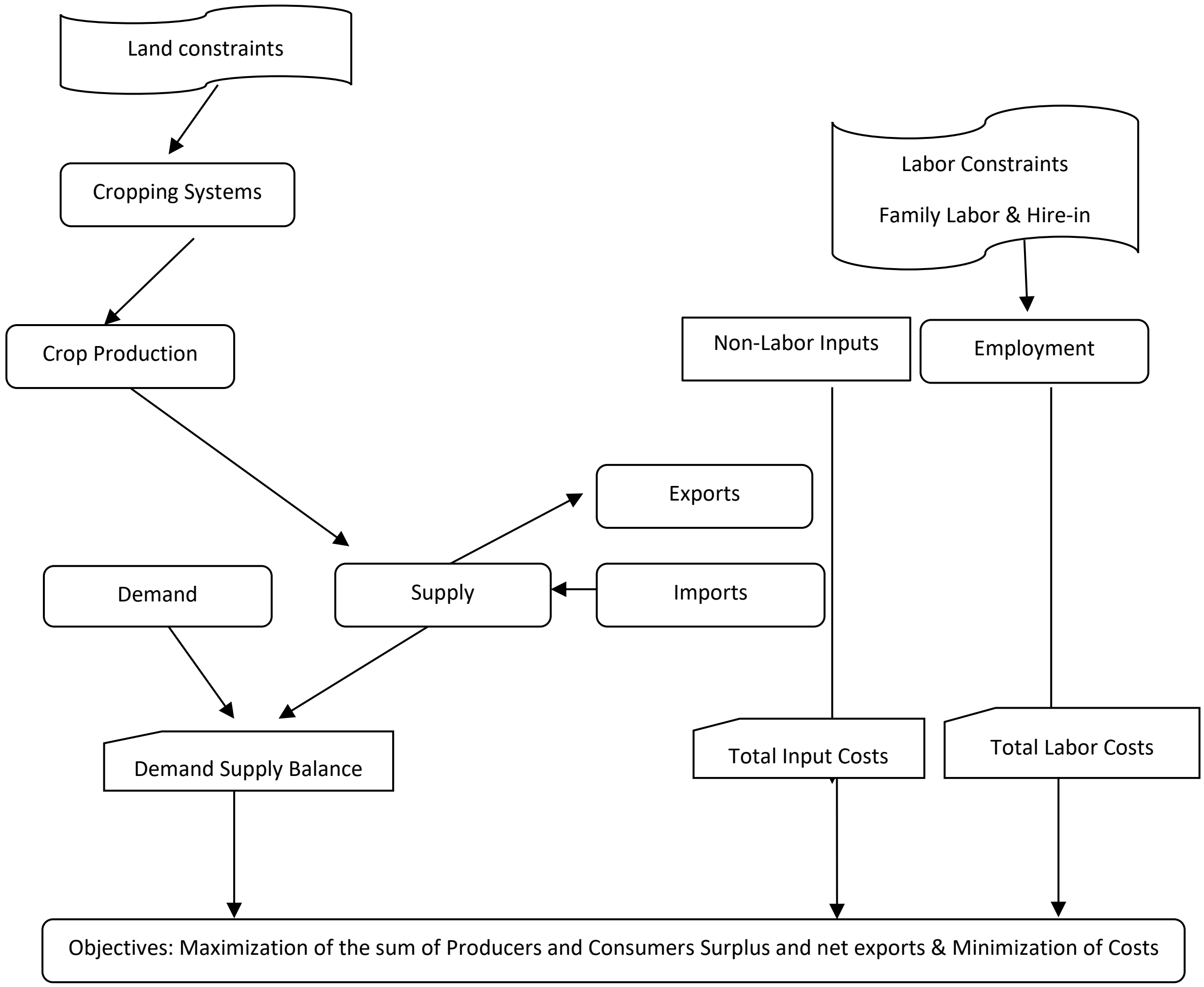
The empirical evidences over the past decades have left the debate open, since high levels of protection in some countries has contributed to a slowdown in production. For example, in Nigeria, a study conducted by Dorosh and Malek (2016[8]) showed that an increase in the import tariff on rice from 50 percent in December 2012 to 110 percent in January 2013 did not benefit producers as incentives offered by the tariff increase were offset by disincentives from real exchange rate appreciations. On the other hand, a study conducted by Conteh, Yan, and Sankoh (2012[9]) in Sierra Leone showed a positive and significant relationship between the quantity of rice produced and the domestic price of rice in the market and that a 1 percent increase in the price of domestic rice will result in a 114 percent increase in rice production in the country.

IV. The Model

The model developed for the Sierra Leone rice sector is a partial equilibrium programming model which solves for a nonlinear objective function representing the sum of producers' and consumers' surpluses in the rice market. The sum of producers' and consumers' surpluses is maximized subject to inputs, state of technology and balance constraints. More specifically, the model describes domestic production, imports, domestic demand and exports for rice. It is a single period model for the 2018 base year but may also be solved for any future target year. The model is seasonally disaggregated for the two major factor inputs, land and labor. The production side of the model is disaggregated in terms of the five major ecosystems for rice. On the demand side of the model, market-clearing price is endogenous and is determined by both demand and supply conditions. The broad structure of the model is set out in figure 3 below.

[7] Shiells, Clinton R., Robert M. Stern, and Alan V. Deardorff, "Estimates of the Elasticities of Substitution between Imports and Home Goods for the United States" 1988.
[8] Paul A. Dorosh and Mehrab Malek, rice imports, prices, and challenges for trade policy, (IFPRI 2016) https://www.ifpri.org/publication/rice-imports-prices-and-challenges-trade-policy.
[9] Alhaji Mohamed Hamza Conteh*, Xiangbin Yan, Foday Pinka Sankoh, The influence of price on rice production in Sierra Leone (2016) https://www.scirp.org/journal/paperinformation.aspx?paperid=20164.

Figure 3: Model Framework



The Model

Max $\sum \boldsymbol{CS} + \boldsymbol{PS} + (\boldsymbol{E} - \boldsymbol{M}) - \boldsymbol{T}\mathbf{cost}$

Where: CS = Consumer's surplus; PS = Producer's surplus; E = Exports; M = Imports; Tcost = Total costs

Subject to:

$\sum_c X_c \ * a_{tc} \leq A$ *{Land constraint}*

Where: X_c *is the level of cropping activity in hectares,* a *is the months (t) of land occupation by rice (c); and A is the total acreage under production being the product of the total number of farms and the average farm size.*

$\sum_c X_c \ * \ l_{tc} \leq \ flab_t + \ tlab_t$ *{Labor constraint}*

Where: l_{tc} *is the total labor use over time (t) and by crop type (c) and* $flab_t$ *and* $tlab_t$ *are the monthly available family labor and temporary labor, respectively measured in person-days.*

Cost block equations:

Variable cost (vcost) = $\sum in_{ic} * prinp_i * X_c$

Miscellaneous cost (mcost) = $\sum X_c * miscost_c$

Temporary labor cost (labcost) = $\sum tlab_t * twage$

Family labor cost (rescost) = $\sum flab_t * rwage$

Total cost = vcost + mcost + labcost + rescost

Production process

National rice production (natprod) = X*yield*conf

Where conf is the conversion factor from paddy to milled rice.

Demand balance

National rice consumption (natcon) = natprod + imports - exports

Policy

Fiscal revenue (govrev) = imports *pm *itax

Where pm is the price of imports and itax is the rate of import tariff on rice

Variables of policy interest

Value of national production (valpro) = $\sum natprod_c * price_c$

Farm income (yfarm) = revenue – tcost + rescost

Employment (employ) = $\sum \sum (X_c * l_{tc})/dpm/12$

Where l_{tc} is the labor used per time per crop and dpm is the number of work days per month

Trade balance (tradebal) = $\sum$ (exports *pe – imports * pm)

Where pe and pm are the prices of export and import, respectively

a. Data

Land availability and use

The country covers a geographical area of about 72,300 km2 (72 million hectares)[10] and nearly three-quarters of the land is suitable for crop production on a sustainable basis. Of this total, 4.3 million hectares (ha) are uplands of low fertility and an estimated 1.06 million hectares of fertile lowlands with considerable potential for food crop production. There are five main types of cultivable land in Sierra Leone: (i) The Uplands account for 80 percent of arable lands, highly leached with low fertility status, suitable for a variety of food and cash crops; (ii) Inland Valley Swamps (IVS) account for nearly 12 percent of arable lands and are highly fertile from hillside runoff; (iii) Mangrove Swamps, which accounts for

[10] (2015 Population and Housing Census)

almost 4 percent of arable lands are subject to sea water flooding during rainy season, is of medium fertility and suitable for rice cultivation if there is no salt intrusion; (iv) Bolilands account for 2 percent of arable lands are seasonally flooded plains of inherently low fertility and difficult to cultivate without proper machinery; (v) Riverine Grasslands, which account for about 2 percent of arable land are flooded during the rainy season, but otherwise fertile and suitable for rice cultivation. Table 1 below shows the constraints on the availability of arable land by ecology and the five rice ecosystems.

Table 1: Availability of arable land by ecology

Ecology	Ecosystem	Arable land area (ha)	% of Arable land
Upland	Upland	4,300,000	80.23
Lowland	Inland Valley Swamp	630,000	11.75
	Mangrove Swamp	200,000	3.73
	Boliland	120,000	2.24
	Riverain Grassland	110,000	2.05
Total		**5,360,000**	**100**

Source: National Rice Development Strategy, Sierra Leone, 2009

According to the 2015 census, the majority (85.4 percent) of Sierra Leone households own or operate a crop farm. About 62 percent of agricultural households grow upland rice, while 31.6 percent of households cultivate lowland rice, which includes inland valley swamp, boliland, mangrove swamp and riverine ecologies. All-together, 93.6 percent of agricultural households grow either upland or lowland rice. Of the total land area of 3,244,214 ha under food crop production, 35 percent is under upland rice production, 17.3 percent is used for lowland rice cultivation, 10.6 percent for cassava cultivation, 9.2 percent for groundnut cultivation, 1.5 percent under sweet potato and 0.9 percent under maize cultivation. In total, about 1.5 million hectares were utilized for rice cultivation in 2015 (Table 2).

The Northern region cultivates the most upland rice with 13.1 percent of land cultivated, compared to the Eastern region (12.4 percent), Southern region (9.3 percent) and Western region (0.2 percent). A relatively lower proportion of land is used for lowland rice, with the Northern region recording the highest proportion of land under lowland rice cultivation (10.3 percent).

Table 2: Sierra Leone Arable Land Area (ha) Utilization by Ecology and by District (2015)

District	Upland	Boliland	IVS	Riverain	Mangrove	Total
Bo	140,668	5,711	18,976	3,097	0	**168,452**
Bombali	60,368	10,547	19,697	1,552	0	**92,164**
Bonthe	75,694	2,008	6,519	7,029	6,201	**97,451**
Kailahun	161,140	0	15,367	0	0	**176,507**
Kambia	55,379	8,181	21,667	5,405	10,016	**100,648**
Kenema	137,132	0	26,038	0	0	**163,170**
Koianadugu	36,112	0	31,668	0	0	**67,780**
Kono	104,521	0	16,215	0	0	**120,736**
Moyamba	91,819	4,760	11,352	1,800	2,428	**112,159**
Port Loko	107,798	5,140	24,154	2,059	5,579	**144,730**
Pujehun	69,164	1,903	6,374	2,844	1,409	**81,694**
Tonkolili	119,754	15,158	33,873	1,550	0	**170,335**
Western Area	15,612	0	2,609	399	2,255	20,875
National	**1,175,161**	**53,408**	**234,509**	**25,735**	**27,888**	**1,516,701**

Source: Sierra Leone, Ministry of Agriculture, 2015

Number of farms

The 2015 Population and Housing Census indicate that some 687,805 households are engaged in rice farming (Table 3). Of this total, 62.3 percent are in engaged in the Upland ecological area and 31.6 percent are in the lowland area. Nearly two-thirds of agricultural households grew upland rice while just under a third cultivated lowland rice, which include inland valley swamp (IVS), boliland, mangrove swamp and riverine ecologies (Population and Housing Census, 2015).

Table 3: Households Engaged in Rice Farming by Region (2015)

Region	Upland Rice		Lowland Rice		Total
	No.	%	No.	%	No.
Sierra Leone	*456,470*	*62.3*	*231,335*	*31.6*	*687,805*
Eastern	158,341	21.6	66,904	9.1	225,149
Northern	187,997	25.7	128,995	17.6	316,992
Southern	107,796	14.7	33,842	4.6	141,638
Western	2,336	0.2	1,594	0.2	3,930

Source: Sierra Leone Population and Housing Census, 2015.

Farm Size

The 2009 National Sustainable Agriculture Development Plan 2010-2030 gives the average farm size as 1.63 hectares, based on the 1985 census. However, the 2015 Population and Housing Census indicates that 1,694,309 hectares of land is under rice cultivation, comprising 1,133,925 hectares of upland and 560,384 hectares of lowland rice. The total estimate is slightly higher than the estimate from the Ministry of Agriculture (Table 2). The 2015 Census puts the average farm size at 2.46 hectares. This suggests that the average farm size increased by 51 percent over the 30-year period between 1985 and 2015.

Labor availability use and earnings

According to the 2014 Sierra Leone Labor Force Survey, the working-age population is just over 3 million. The overall labor force participation rate is 65 percent, with the male participation rate at 65.7 percent and the female rate slighter lower at 64.5 percent. The overall labor participation rate is much higher in the rural areas (69.4 percent) than urban Freetown (53.9 percent). According to the 2014 Labor Force Survey, 59.2 percent of the Labor force is engaged in self-employment in the agricultural sector, with the percentage slightly larger for men than for youth and women (Table 4).

Table 4: Sierra Leone-Employment by Sector

Sectors	Men (%)	Women (%)	Youth (%)	Overall (%)	Rural (%)	Urban (%)
Agricultural, Self-employment	59.7	58.7	58.8	59.2	72.9	0.5
Non-agricultural Self-employment	24.8	36.8	31.9	31.3	23.5	59.0
Wage employment	15.5	4.5	9.3	9.5	3.6	40.5
Unpaid labor	6.6	6.4	7.5	6.5	7.1	2.6
Agriculture, Fishing and Forestry	62.2	60.1	61.1	61.1	74.4	0.6
Mining and Extractive Industries	3.0	0.2	1.2	1.5	1.1	0.1
Manufacturing and Utilities	5.6	0.5	3.1	2.8	2.2	6.5
Construction	2.7	0.1	1.3	1.2	0.5	6.1
Services	26.6	39.2	33.2	33.4	21.7	86.6

Source: 2014 Sierra Leone Labor Force Survey

The 2014 Labor Force Survey shows that men earn nearly three times as much as women in wage employment, more than 2.5 times as much in non-agricultural self-employment, and nearly double in agricultural self-employment. Earnings are lowest in wage-employment in agriculture. However, the agriculture sector makes a larger contribution to poverty reduction than the mining sector (which has the highest earnings) because it provides more, albeit low-wage jobs. Holding the level of employment constant and raising the level of productivity in the agriculture sector could make a significant contribution to reducing poverty in Sierra Leone. Sierra Leone has a minimum wage established by the Regulation of Wages and Industrial Relations Act No. 18 of 1971. The Act provides for a review of the minimum wage every two years, and the most recent review in 2015 established Le500,000 (equivalent to about US$88.67) as the monthly minimum wage.

As table 5 below shows, the peak seasons for labor demand in the rice sector is around April to June (land preparation and planting) and then September to November (bird scaring and harvesting).

Table 5: Seasonal use of labor by rice ecosystems (person-days)

Season	Upland	Boliland	IVS	Riverain	Mangrove	Total
January					0.5	**0.5**
February	9.8			1.2	0.5	**1.7**
March	9.8	11.6	14.0	1.2		**36.6**
April	18.2	11.6	29.0	7.7	15.0	**81.5**
May	8.3	18.7	29.0	6.5	15.0	**77.5**
June	16.8	10.2	22.3	11.5	16.0	**76.8**
July	8.5	6.8	13.2	5.0	9.8	**43.3**
August		6.8	20.5		8.8	**8.8**
September	35.3	3.8	20.9	32.5	8.8	**101.3**
October	39.6	15.9	34.9	34.2	18.4	**143.0**
November	10.1	12.1	49.9	4.8	10.2	**87.1**
December		12.1	18.4		10.2	**10.2**
Total	**85**	**109.6**	**252.1**	**71.5**	**112.2**	**668.3**

Source: Authors calculations

For the model, labor is specified in two broad categories, temporary labor and family labor. Temporary labor is assumed to be hired daily at a wage rate given by the minimum wage law, which for 2018 was Le500,000 per month or the equivalent of US$3.38 per day.[11] Family labor is priced at a daily "reservation wage" that is higher than zero but lower that the daily rate for the hired-in labor. From the 2015 Population and Housing Census, the average household size is 5.6, with rural household generally larger (6) than urban households (5.1). The average farm family is assumed to have six (6) members, of whom 2 are adults and deliver a total of 20 person-days of labor per month. The family labor constraint may be relaxed through the hiring of temporary labor on a daily or weekly basis. Although the family worker is paid the reservation wage, which is assumed to be lower than the wage for temporary workers, all workers are assumed to have the same level of productivity.

Fertilizer availability and use

The use of fertilizer is well below the requirement. In 2015, only 3.8 percent of farmers reported applying chemical fertilizer and 9.7 percent of farmers reported applying organic fertilizer. Most farmers (41

[11] It is of course recognized that the actual wages may in fact be lower than the minimum wage, given the high level of unemployment. If this is the case as is likely then *a priori* the model would be likely to underestimate the level of employment.

percent) source their fertilizer from the market (shops and traders) while 39 percent rely on Government for the supply. A small share of farmers (5 percent) rely on NGOs for their supply of fertilizer.[12]

Mechanization

The level of agricultural mechanization is very low in Sierra Leone. According to data for the 2015 Population and Housing Census, only 6.3 percent of households had access to tractors, less than 6 percent to power tillers and only 3.4 percent to threshers for rice. Access to rice mills is higher, with slightly more than half of households having access to rice mills. There is also a significance difference in the access to tractors between urban and rural area, with the access rate for urban areas at 10.4 percent but only 5.6 percent for rural areas. The access to power tillers, threshers and rice mills show similar variances. In terms of regions, the Northern Province has the highest access to tractors and power tillers, while the Eastern region has the highest access to rice mills (Table 6).

Table 6: Share of Households with access to mechanization by type

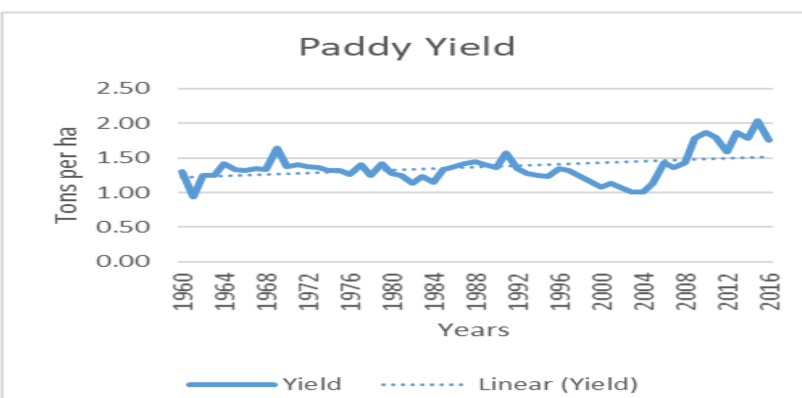
Location	Tractors	Power Tillers	Threshers	Rice Mills
Sierra Leone	*6.3%*	*5.9%*	*3.4%*	*50.1%*
Rural	5.6%	5.2%	3.1%	46.6%
Urban	10.5%	10.2%	5.0%	69.5%
Eastern Province	3.1%	5.3%	3.2%	65.6%
Northern Province	9.5%	6.3%	3.0%	53.8%
Southern Province	6.2%	6.2%	4.3%	24.6%
Western Province	6.3%	4.5%	4.3%	12.0%

Source: Sierra Leone, Population and Housing Census, 2015

Rice yields

Rice yields are historically low in Sierra Leone averaging only 1.36 tons of paddy per hectare over the almost 60 years between 1960 and 2016 (Figure 4). Low yields result from a number of factors including poor seed quality, low input use, including fertilizer and poor crop management. Yields have picked up slightly since the end of the civil war in 2002 and the introduction of higher yielding varieties including Nerica.

Figure 4: Rice Yield in Sierra Leone (1960 -2016)



[12] State of Food Security in Sierra Leone, 2015, Comprehensive Food Security and Vulnerability Analysis.

Rice yields are generally variable across Sierra Leone and depend on the agro-ecological zone. Yields are highest (>2.5 tons per ha) in mangrove zones, then riverine (about 2.5 tons per ha), then inland valley swamps – IVS (> 1.5 tons per ha but less than 2.0 tons per ha), then boliland and upland (about 1 ton per ha on average). The yield assumptions for the five ecologies in the model are calculated from acreage and production information provided by the Ministry of Agriculture for 2016. It is assumed that there has been no significant change in yields between 2016 and 2018. This is not a restrictive assumption as the impact of the variation in yields on consumption, exports and imports can be simulated.

Table 7: Sierra Leone, Cultivation, Production and Yield of Rice in All Ecologies (2016)

District	Upland Rice		IVS Rice		Boliland Rice		Riverain Rice		Mangrove Rice	
	Area (ha)	Prod (Mt) Paddy	Area (ha)	Prod (Mt) Paddy	Area (ha)	Prod (Mt) Paddy	Area (ha)	Prod (Mt) Paddy	Area (hHa)	Prod (Mt) Paddy
Bo	78,311	70,871	7,286	13,901	1,098	1,270	4,834	12,061	0	0
Bombali	54,654	44,598	16,659	26,388	4,850	3,989	4,212	11,859	0	0
Bonthe	7,384	7,923	9,048	15,020	1,421	1,449	4,240	11,908	3,221	10,178
Kailahun	73,989	82,646	21,836	37,645	0	0	4,309	11,524	0	0
Kambia	32,124	29,008	20,406	45,036	4,671	4,297	3,499	8,956	872	2,486
Kenema	96,557	90,570	15,959	26,731	0	0	3,554	9,168	0	0
Koinadugu	48,183	51,074	19,148	52,121	3,542	3,797	2,640	8,762	0	0
Kono	56,743	59,921	19,422	29,366	0	0	2,168	5,507	0	0
Moyamba	68,585	64,401	7,874	13,386	2,330	2,796	3,987	11,164	1,724	4,931
Port Loko	53,448	45,645	22,779	33,576	4,742	5,121	4,753	9,506	3,247	9,221
Pujehun	31,218	33,122	8,816	12,395	1,261	1,319	3,048	7,803	1,023	2,949
Tonkolili	58,954	62,786	20,799	29,930	3,570	3,213	3,028	8,197	0	0
W/Area	2,365	2,247	543	992	180	184	1,373	3,165	287	679
National	**662,515**	**644,812**	**190,575**	**336,487**	**27,665**	**27,435**	**45,645**	**119,580**	**10,374**	**30,444**
Average Yield		***0.97***		***1.77***		***0.99***		***2.62***		***2.93***

Source: Ministry of Agriculture, Sierra Leone, 2016

Paddy harvesting activities include reaping, stacking, handling, threshing, cleaning, and hauling, all labor-intensive activity in Sierra Leone. Most rice varieties are composed of roughly 20 percent rice hull or husk, 11 percent bran layers, and 69 percent starchy endosperm, also referred to as the total milled rice. Milling is an important step in the post-production of rice, involving the removal of husk and brand layers to produce an edible output of kernels with minimum breakage and free of impurities. The by-products in rice milling process are rice hull, rice germ and bran layers, and fine broken kernel pieces. Milling yield is usually determined according to the procedure of the International Rice Research Institute (2009b) using the formula:

Milling yield = [Weight of white rice/ Weight of paddy] x 100.

In Sierra Leone, and average of 60 percent of milled rice is recovered from the paddy. This is the conversion factor that is assumed in the model. Appaiah et al (2011) found that in Ghana the advanced mills demonstrated a conversion factor of 67.3 percent, the inefficient mills were at 50 percent and the locally made mills operated at 47.1 percent conversion. Singha (2013) found conversion factors for India in the range of 64 percent for the modern mills and 58.6 for traditional mills.

Rice Market

Supply

The supply of rice to the Sierra Leone market comes from three primary sources; (i) domestic production from the five rice ecosystems, (ii) commercial imports and (ii) donations (food aid). Domestic production of milled rice has averaged 620,000 metric tons over the last ten years to 2018. According to the 2015, Comprehensive Food Security and Vulnerability Analysis, more than nine out of every 10 rice farmers reported that they sold a portion of their rice harvest to generate income. This is despite the fact that a clear majority of farmers (96 percent) operate at the subsistence level. It has been argued that the subsidization of imported rice is a major disincentive to farming household producing consistent surpluses, as they cannot compete with the price for imported rice.

Empirical work suggest that the supply of rice is elastic with respect to price. Conteh et al (2012) used an Ordinary Least Squares (OLS) log model with a small sample (2001 -2010) to analyze the domestic supply response to price as well as the effects of the price of imported rice. They found a supply response elasticity with respect to price of 1.14. Although imported rice is normally considered a substitute for domestic rice and *a priori*, the elasticity coefficient is expected to be negative, the coefficient for the price of imported rice was 0.69. Their plausible explanation for the positive coefficient is that increase in domestic production of rice (which does not meet the quality standard of the urban population) does not cause a decline in the quantity/volume of rice imported into the country, since the urban population depend on the imported rice for their consumption. Kargbo (1979) also used OLS technique with a single equation model to estimate the supply response to price. The analysis is based on data from 1961 to 1976. He found an inelastic supply response with elasticities of 0.178, 0.376 and 0.349, respectively for the linear, semi-log and log-log specifications of the supply response model. Kargbo (1979) argued that the low elasticities reflected the government's pricing policy, which effectively held down the price paid by consumers and prevented it from rising to provide farmers with an incentive to increase production or adopt new methods.

Annual commercial imports of rice averaged over 400,000 metric tons per year, over the five-year period to 2018, at an average cost of US$140 million per year, as domestic production has failed to keep pace with Sierra Leone rapidly growing population. There is no consistent data on rice food aid that enters the market. Although the channel and structure for the marketing of domestic and imported rice are similar (see Spencer et al, 2009), consumer surveys suggest that the imported rice is more available. Overall, nearly 90 percent of households across both urban and rural districts indicated that imported rice was always available in their nearest market, compared with only 49 percent of households for domestic rice. The exception being the Western urban area, where 95 percent of households indicated that domestic rice was always available. The Western area is also the most urban and inhabited by the relatively higher-income population with the means to afford imported rice.

Table 8: Supply of rice to the Sierra Leone market (2009 – 2018)

Year	Total Supply	Domestic Production	Imports	
	Volume (Mt.)	*Volume (Mt.)*	*Volume (Mt.)*	*Value (US$'000)*
2009	698,840	592,570	106,270	45,169.00
2010	685,569	616,003	103,500	43,950.00
2011	833,011	677,603	155,408	84,726.48
2012	941,906	684,850	257,056	111,395.54
2013	1,085,819	753,335	332,484	129,385.30
2014	897,066	489,908	407,158	120,719.50
2015	917,560	597,216	320,344	141,490.03
2016	1,029,709	695,255	334,454	96,886.67
2017	1,149,547	538,241	611,306	191,380.19
2018	959,513	551,751	407,762	120,083.47

Source: Based on data from Ministry of Agriculture and Food Security and Bank of Sierra Leone

Rice price

Government's policies with respect to the incentive framework have had a serious negative effect on agricultural production. The overvalued leone imposed low producer prices for rice, since imports at the low rate of exchange depressed the domestic urban market price. The price of rice in the retail market in 2016 was Le4,887.05 per kilogram.[13] This is equivalent US$769.76 per ton based on the exchange rate of Le6348.79 per US$ in 2016. The world price of US$396 per ton and the implicit average cif price of US$289.68 calculated from Table 8 would suggest that the mark-up on rice to the final consumer is substantial—more than a doubling. However, since the price of imported rice is variable over the months, reaching and average cif of US$440.34 between June and December 2016, it is assumed that the risk averse, profit-maximizing importer/distributer would base the final price on the US$440.4 cif price rather than the lower US$289.68 per ton. The average price of rice increased to Le12,831 per kilogram in 2018, in large part because of the substantial depreciation of the leone, as the world market price increased by only about 2 percent between 2016 and 2018. With the exchange rate of Le 7,393.57 per US dollar the 2018 retail price amounts to Le 4,877 per kilogram or US$660 per metric ton.

The reference or border price of imported rice used in the model is given algebraically as:

$P_b = (P_w + T_w) + T_d - C_b$; and the export border price is given as:

$P_b = P_w - T_w - T_d - C_b$

Where:

P_b is the reference price at the farm gate;

P_w is the world price;

T_w is the shipping and insurance charges;

$P_w + T_w$ represents the CIF price at the domestic port;

[13] Based on the CPI survey conducted by Statistics Sierra Leone.

T_d is the handling and transport charges from the border to the domestic market;

C_d is the transport, processing and marketing charges from farm gate to the domestic market.

Demand

The national demand for rice in Sierra Leone is a function of the growth in population, the increase in income and the income elasticity of demand. The rate of increase in national demand can be given by the following formula:

ND = pr + ie*pc

Where: ND is the rate of increase in demand; pr is the rate of population growth; ie. is the income elasticity of demand for rice and pc is the rate of increase in real per capita income.

Based on the United Nations projections, Sierra Leone population will grow at about 2.3 percent per annum over the next five years, assuming constant fertility.[14] The real per capita GDP is also projected to be relatively flat to declining over the same period.[15] Assuming income elasticity of demand between 0.5 and 1, Sierra Leone's national rice demand would grow in line with its projected population growth of 2.3 percent or marginally below.

Since rice is a normal and staple food for Sierra Leoneans, a priori, it is expected that the price elasticity of demand would be negative and low (inelastic). That is, an increase in the price of rice would lead to only a small decrease in the quantity of rice demanded. Kargbo (1979) used OLS technique and linear, semi-log and log-log model specifications to estimate demand elasticities for rice in Sierra Leone. His estimations yielded elasticities of -0.294, -0.309 and -0.309 for the linear, semi-log and log-log specifications respectively. This was the only study that could be found in a very thorough, but non-exhaustive search of the Literature on Sierra Leone. A review of the broader literature across several countries showed very variable own price elasticity of demand for rice ranging from as low as -0.10 for South Africa to as high as -0.77 for Tanzania (Table 9).

Table 9: Own price elasticity of demand for rice in selected countries

Country	Elasticity	Date	Methodology	Author(s)
Indonesia	-0.13	1985	OLS	Koo et al
Sierra Leone	**-0.294**	**1979**	**OLS**	**Kargbo**
Thailand	-0.42	1978	OLS	Wong
	-0.392	2008	AIDS	Isvilanonda and Kongrith
Taiwan	-0.61	1996	AIDS	Huang and Bouis
Bangladesh	-0.45	1994	AIDS	Ahmed and Shams
Philippines	-0.50	2013	LA/AIDS	Lantican et al.
Tanzania	-0.77	2014	LA/AIDs	Lazaro Edith Ezra
South Africa	-0.10	2002	AIDs	Agbola et al.

Note: OLS =Ordinary Least Squares; AIDS = Almost Ideal Demand System; LA/AIDs= Linear Approximate Almost Ideal System

[14] United Nations, World Population Prospects, 2019.

[15] See IMF Country Report No. 18/371. December 2018.

b. Government policy

Colonial governments especially in the early stages pursued a relatively non-interventionist policy to agricultural development in Sierra Leone, apart from support to agricultural research and limited training. Later interventions in irrigation and drainage schemes, rice seed multiplication and distribution, mechanization and rice milling, and marketing schemes largely failed because of poor staffing, poor management, inadequate funding and lack of knowledge of local socio-economic conditions (National Rice Development Strategy, Sierra Leone, 2009).

In the immediate post-independence period, agricultural policy shifted to direct intervention in agricultural production by the State. The Rice Cooperation established in 1961 operated its own rice farms and provided cultivation services to farmers. The Corporation offered prices that were below world market prices. Its rice mills were idle for significant periods and the Corporation concentrated its efforts on the more profitable importation of rice, which was a disincentive to local production. However, by 1967, the Rice Cooperation could not raise operating capital to pay farmers cash for produce and resorted to IOUs and the government was forced to close the Corporation in 1978. When the Rice Cooperation was closed, the mandate for the implementation of the rice policy fell to the Sierra Leone Produce Marketing Board (SLPMB). Over the next 10 years the SLPMB also implemented a policy that was very unfavorable to domestic rice producers (Spencer, et al, 1996). Its monopoly was removed in 1986 and the private sector assumed responsibility for the marketing of both locally produced and imported rice.

The government's rice policy is expressed in its National Rice Development Strategy (NRDS, 2009). The goal of the National Rice Development Strategy (NRDS) is to establish a framework for significant increases in rice production to contribute to the improvement of food security and economic development in Sierra Leone. The specific objectives are to: (i) Ensure an increase in the sustainable productivity and production of rice in Sierra Leone; (ii) Promote appropriate post-harvest handling, processing and marketing of rice; (iii) Develop appropriate infrastructure for rice production and marketing; and (iv) Improve the capacity of stakeholders and institutions involved in rice sector.

The strategy for increasing rice production is two-pronged: (a) increase in area cultivated, mainly in the lowlands where there is much underutilized capacity, and (b) increases in productivity per unit area in all ecosystems. Area expansion will mainly be in the IVS due to its existence in all parts of the country coupled with its potential for sustainable production. The government's goal is to achieve rice self-sufficiency. This strategy targets a land area of 830,000 hectares and an increase in the average rice yield/ha to 2 mt/ha to realize the government's self-sufficiency goal.

V. Results

The primary purpose of the rice sector model is to simulate the effects of policy interventions, most notably the impact of the removal of the ECOWAS tariff waiver. It is therefore important to ensure that the model captures the salient features of the Sierra Leone rice sector and that the base year results are validated against the actual data generated from surveys and other sources for the selected base year. Since 2016 is the most recent year for which there are yield and production data across the five ecologies, it is adopted as the base year. Also, since it is possible that rice farmers may not behave optimally in their choice of production pattern and the use of inputs (see Kutcher and Scandizzo, 1981) and the fact that rice price has substantially increased between 2016 and 2018, the model is also run for 2018 in a more normative vein to simulate the effect of using more lands in the riverain and mangrove ecologies, given that the yields are much higher in these ecologies but levels of cultivation are well below the upper bounds, suggesting sub-optimal use.

Model validation

To replicate the base year, equivalent to the 2016 survey data, it was necessary to establish upper bounds on acreage for the two ecologies with the highest yields i.e. 'riverain' and 'mangrove' and lower bounds for the other three ecologies at the base-year level of cultivation. This was necessary to avoid any misspecification of the model constraint set (See Nugent, 1970). The rationale for doing this is that in the unbounded simulations, more use acreages were allocated to these ecologies as the model 'optimized' the objective function. This is already an important finding that suggests that the sector is operating at a sub-optimal level with respect to the maximization of consumer and producer welfare in not expanding the acreage in these two ecologies to take advantage of the higher yields, other things being equal. Lower bounds were established for each of the other ecologies to reflect the respective current base year land usage (area under cultivation).

As table 10 below shows, the model is well validated by the available base year survey data on domestic price, consumption, domestic production and imports. There is currently no export of rice from Sierra Leone, as is reflected in the survey data as well as the model results.

Table 10: Baseline results of the model compared with survey data

Scenario	Consumer & Producer Surplus (US$ Mn)	Domestic Consumption (MT)	Domestic Production (MT)	Imports (MT)	Price (US$/MT)	Trade balance (Rice) (US$ Mn)	Employment (Numbers)
Survey data (2016)		**1,029,709.0**	**695, 255.0**	**334,454.0**	**770.00**	**(257.5)**	**732,461.0***
Model baseline	1,328.3	1,030,210.9	694,394.4	335,816.5	768.6	(258.6)	669,340.0
% Deviation		0.05%	0.12%	0.41%	0.18%	0.43%	8.62%

Note* Number of heads of agricultural households.

In the baseline simulation, all the results show absolute differences of less than 1 percent from the 2016 survey data, except for the employment data. The model simulated employment is 63,121 less (8.62 percent) than the survey data of 732,461. It is not clear whether this is a lower employment bias from the model since the survey data is only recording the number of heads of agricultural households. It may be possible that such household heads may in fact be employed outside of the rice sector while their rice farms remain fallow. Furthermore, since the model is 'efficient' in the allocation of labor resources, the difference may be truly reflective of the underemployment in the rice sector.

To allow the model to fully optimize the objective function in a more normative sense, only upper bounds on acreage were set to reflect the physical land availabilities in all five of the rice ecologies as represented in Table 1. This adjustment is equivalent to changing the land constraint to:

$\sum_c X_c \, * a_{tc} \leq \; \sum_E A$ *{Land constraint}*

Where E represents the five main ecologies.

The results of this normative baseline simulation are shown in Table 11 below. The simulated opening of the Riverain and Mangrove ecologies, the two most productive, produced some dramatic shifts in the rice sector. First, the consumer/producer surplus is 5.5 percent higher (US$1,401.6 million) compared to

US$1,328.3 million for the initial baseline. A major reason for this is that price is 18.8 percent lower. However, overall consumption falls by 3 percent. This is driven by the lower consumption from rice producing households, which suffer a loss in income as a result of the lower price for rice. The simulation also suggests that given the current technical and economic parameters, in order to maximize consumer/producer surplus, the total domestic production of rice (524,520 Mt) should only be produced in the Mangrove (351,600 Mt) and Riverain (172,920 Mt) ecologies and no rice should be produced in the Upland, IVS and Boli ecologies. This reflects a dramatic shift for the current spatial distribution of the crop. Furthermore, the marginal value (shadow price) of the upland land acreage in the model results is US$ -166.28, suggesting that if an additional hectare of upland rice was included, the overall consumer/producer surplus would fall by US$166.28. In contrast, the marginal value of Mangrove land is US$ 191.70, suggesting that if one more hectare of Mangrove land could be added beyond the current bound the total consumer/producer surplus would be increased by US$191.70.

Table 11: Results of the model with Acreage Upper bounds compared with survey data

Scenario	Consumer & Producer Surplus (US$ Mn)	Domestic Consumption (Mt)	Domestic Production (Mt)	Imports (Mt)	Exports (Mt)	Price (US$/Mt)	Trade Balance (US$ Mn)	Employment (Numbers)
Survey data (2016)		**1,029,709.0**	**695,255.0**	**334,454.0**		**770.0**		**732,461.0***
Normative Baseline	1,401.6	1,002,010.2	524,520	861,521.5	384,030	624.11	(413.5)	142,280

Source: Survey data and Model output

Interestingly, because of the low import price (in part due to the duty waiver) the simulation also suggested that to maximize consumer/producer surplus, Sierra Leone should import 861,521.5 Mt of rice and export 384,030Mt of rice. However, this would leave the country with a substantial rice trade balance deficit of US$413.5 million. Under the current technical and policy environment for the rice sector in Sierra Leone, maximizing consumer and producer surplus would also lead to a sharp reduction in employment in the rice sector. The results of the simulation show employment falling to 142,280, from 669,340 in the initial baseline—a substantial reduction of nearly 79 percent. Most of this reduction in labor would come from the ecologies where no rice would be produced. While this outcome may be optimal in terms of the maximization of consumer and producer surplus, it does not appear to be feasible in terms of employment and the balance of payments. The next section of the paper discusses the policy experiments, which considers the impact of removing the tariff waiver and increasing the tariff as well as the impact of increasing the minimum wage.

Policy Experiments

Tariff simulations

The normative model is used to simulate the impact of tariff increases on several policy parameters of interest including prices (which are endogenous), consumer and producer surplus, domestic consumption, domestic production, imports, exports, the rice trade balance and employment. The results of the simulation, assuming four different levels of tariffs on rice imports are shown in Table 12 below.

A 1 percent tariff on rice imports, would, other things equal, results in an increase in domestic price to US$856.69 per ton, or approximately an 11 percent increase above the price at the time of the latest survey (2016). This increased price would, other things equal elicit a substantial supply response from farmers, pushing domestic production of rice from 694,394.4 tons to 1,224,120 tons—a 76.3 percent increase. The increased price of imported rice occasioned by the tariff imposition and the robust domestic supply response would also lead to a large decline in rice imports from 335,816.5 tons to 115,736.8 tons and a consequent improvement in the rice trade balance (Table 12).

Table 12: Results Tariff Simulation

Tariff level	0%	1%	5%	10%	15%
Key policy indicators	Normative Baseline				
1. CPS (US$ Mn)	1,401.6	1,192.5	1,189.5	1,187.9	1,187.9
2. Employment (No.)	142,280	893,140	895,600	958,370	958,370
3. Consumption (Mt)	1,002,010.2	909,536.1	908,370.7	907,743.2	907,743.2
4. Production (Mt)	524,520	1,224,120	1,226,460	1,291,774.5	1,291,774.5
5. Imports (Mt)	861,521.5	115,736.8	109,909.8	-	-
6. Exports (Mt)	384,030	430,330	427,990	384,030	384,030
7. Trade balance (Mn$)	(413.50)	96.70	96.74	155.15	155.15
8. Fiscal Revenues ($)	-	154,300	761,670	-	-
9. Price ($/Mt)	624.11	856.69	860.10	861.80	861.80
10. Price increase (%)		37.3	0.4	0.2	0.0

Source: Model output and authors calculations

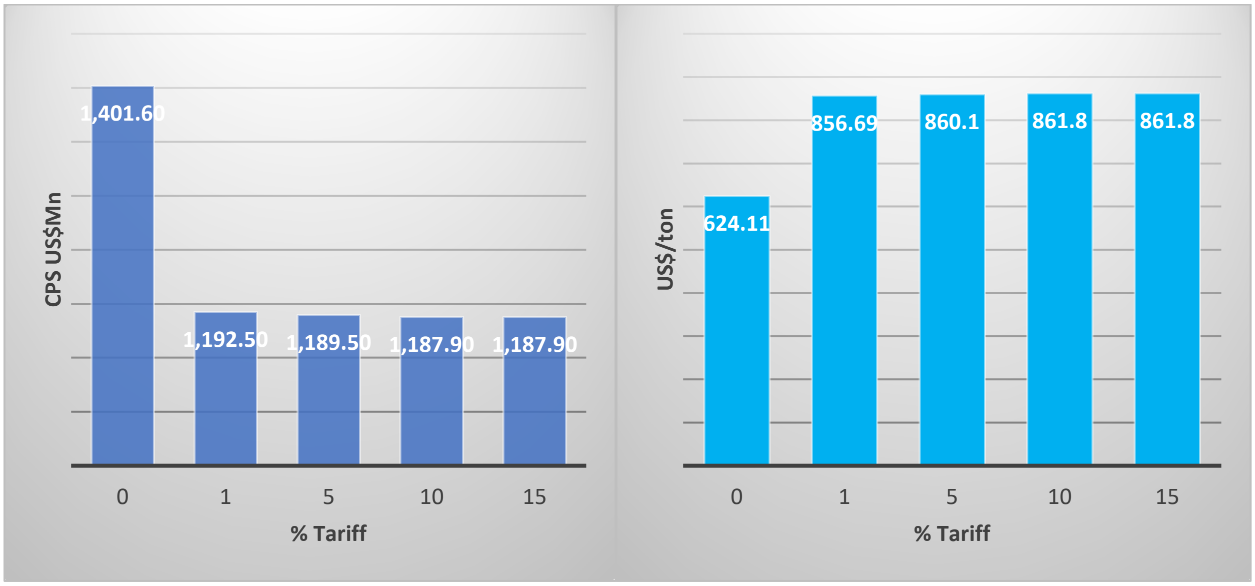
On the consumption side, because of the increase in price, total domestic consumption of rice would drop from the base level of 1,029,709.0 tons to 909,536.1 tons—an 11.7 percent decline. At the same time, the level of consumer/producer surplus would decline by 10.2 percent from US$1,328.3 million to US$1,192.5 million. The decline in the sum of consumer and producer surplus results from the fact that the total decrease in consumer surplus resulting from the price increase, which reduces demand, is larger than the increase in producer surplus resulting from the higher price. This is not surprising as many producers are also consumers.

The 1 percent tariff on imported rice also provide a positive impact on employment through the demand for increased labor, some of which is provided by temporary labor. As table 12 shows, the level of employment in the rice sector increases from the base level of 669,340 to 893,140—a substantial increase of 33.4 percent. Much of this increase comes from the 365,805 temporary workers added, as household employment falls by 21.2 percent to 527,335. Imposing a small 1 percent tariff on rice imports would therefore be good for domestic job creation.

Table 12 also shows the impact of further increases in the tariff level up to 15 percent. A 10 percent tariff result in an increase in domestic prices to the equivalent of US$861.8 per metric ton and would ultimately reduce imports to zero as the domestic supply response would put the domestic production in balance with the lower level of domestic consumption, which results from the higher price. Domestic employment would increase, but only marginally beyond the level when the tariff is set at 5 percent. The rice trade balance would be a surplus of US$155.15 million, since there is no import of rice, but exports of 384,030 Mt tons of rice at this level of tariff.

As Table 12 clearly shows, increasing the tariff beyond 10 percent, has little or no impact on the Market as with tariff at 10 percent the market would essentially become a domestic market with exports but no imports.

Figure 5: Effect of Tariff on: (a) Consumer/Producer Surplus, and (b) Price



Source: Based on model simulation

In summary, what we observe from a policy to increase tariff in line with the ECOWAS position is, on the one hand, a reduction in the sum of consumer and producer surplus from the baseline level, but on the other hand, a narrowing of the trade balance and an increase in employment in the rice sector. This outcome assumes that labor is mobile, including between ecologies and that farmers who increase their acreage of rice beyond the level that can be supported by the available family labor will be able to find temporary labor to hire at the current wage.

Minimum wage increase simulation

Since Sierra Leone has a minimum wage, which was established by the Regulation of Wages and Industrial Relations Act No. 18 of 1971, and the said Act provides for a review of the minimum wage every two years, it is useful to understand the impact of an increase in the minimum wage on the rice sector. Since job creation is also an important issue for the government, the model is used to: First, simulate the impact of a 10 percent increase in the minimum wage, keeping other things the same. Second, simulate the impact of a 10 percent increase in the minimum wage, assuming a 1 percent tariff on imported rice and, finally, simulate a 10 percent increase in the wage rate under the assumption of a 5 percent tariff on imported rice. The results of the simulations are shown in Table 13.

Increasing the minimum wage under a zero-tariff regime has very little impact on the employment in the rice sector, in large part because much of the labor are from farm-owning households and there are no temporary workers hired by farms.

Increasing the minimum wage by 10 percent under a 1 percent tariff regime, changes both the labor and rice market dynamics. Household labor falls by 1 percent and the demand for temporary labor drops by nearly 6 percent on account of the higher wages. The reason for the former is less clear. But one plausible explanation, in keeping with labor market theory, is that the 10 percent increase in wage would meet the reservation wage threshold of some household-farmers, who would then be willing to hire themselves out, including as temporary labor in other non-farm sectors. Importantly, the higher cost of labor pushes up prices by 5.8 percent and as a result consumption falls by 2.3 percent. Domestic production falls by 2 percent, primarily from the least productive areas, including the Upland and IVS ecologies. The higher price for domestic rice also makes imports more attractive, notwithstanding the 1 percent tariff and therefore imports increase by 5.1 percent and consequently the fiscal revenues from the tariff also increase by an equivalent percentage.

Table 13: Results Wage Simulations

Minimum Wage Increase (%)	Baseline	0	10	10	10	10
Tariff Level	0%	1%	1%	5%	10%	15%
Key policy indicators						
11. CPS (US$ Mn)	1,401.6	1,192.5	1,163.5	1,160.3	1,156.6	1,154.9
12. Employment (No.)	142,280	893,140	866,840	869,300	872,370	934,300
13. Consumption (Mt)	1,002,010.2	909,536.1	888,723.6	887,558.2	886,101.4	885,377.9
14. Production (Mt)	524,520	1,224,120	1,199,740	1,202,080.0	1,205,000.0	1,269,409.1
15. Imports (Mt)	861,521.5	115,736.8	121,674.2	115,847.2	108,563.4	-
16. Exports (Mt)	384,030	430,330	432,700	430,370	427,450	384,030
17. Trade balance (Mn$)	(413.50)	96.70	93.70	93.59	93.88	155.15
18. Fiscal Revenues ($)	-	154,300	162,220	802,820	1,576,300	-
19. Price ($/Mt)	624.11	856.69	906.60	861.80	914.91	916.90

Source: Model Simulation

Increasing the minimum wage by 10 percent under a 10 percent tariff regime, would result in an overall 9 percent reduction in total employment in the rice sector. This is comprised of a 3.8 percent reduction in the use of household labor and a much larger, 15.8 percent reduction in the demand for temporary labor. This suggest that employment, and particularly temporary employment in the rice sector is extremely sensitive to the wage rate. As Table 13 shows, it would require a tariff level above 10 percent to fully mitigate the adverse employment effects of the 10 percent increase in the minimum wage.

In summary, the results of the simulation of the increase in the minimum wage suggest that employment in the rice sector is highly sensitive to the wage rate. Furthermore, hired-in labor (who are generally from the poorest groups) are likely to be most adversely affected by the unemployment that would likely result from the increase in the wage rate as suggested by the simulations.

Technical Experiments

A central pillar of the government's agricultural strategy is to increase productivity in the rice sector, by increasing yields through better agricultural practices and the use of improved seeds and increased use of fertilizer. Indeed, the government has taken steps, with the support of the World Bank to liberalize the seed and fertilizer markets to ensure better access to these inputs at more competitive prices.

A report of farmers' field trials with rice production in 1979 suggests that yields could be substantially increased with improved practices. Table 14 below shows the orders of magnitude of such increases.

Table 14: Rice Yields with Improve Practice

Ecosystem	Traditional Practice t/ha	Improved Practice t/ha	% Change
Uplands	0.8	1.4	75.0
IVS	1.7	2.3	35.3
Boliland	1.5	2.0	33.3
Mangrove Swamp	2.8	4.0	42.9

Source: Baggie I., Lamin A.S., Lahai M.T. Inland Valley Research and Development, Sierra Leone

The model is used to simulate the result of an experiment, which assumes that rice yields across the four ecologies covered in the trials increase to levels indicated for improved practice. Since the trials did not cover the Riverain ecology the yield from this ecosystem was held at the current level (2016 survey baseline) for the simulations. The results of the simulation are shown in Table 15. Producers clearly benefit as domestic production of rice rises by 40 percent from the 2016 survey baseline to 974,833.7 tons. Consumers also benefit as the price of rice would fall from US$768.64/ton to US$594/ton, a reduction of 23 percent. This benefit to both consumers and producers is reflected in the fact that the Consumer/Producer surplus would increase from US$1,328.3 million to US$1,486.0 million.

The simulation also suggests that the increased yields relative to baseline is both land and labor augmenting as the entire Upland and a substantial part of the Boliland ecologies would be unutilized and the total employment in the rice sector would fall from 669,340 in the baseline to 377,600. Furthermore, with this technical progress the value of domestic production of rice would rise by 86 percent to US$726.25 million, thereby providing a substantial boost to the domestic economy.

Simulating the impact of the technical progress of increased yields under the various tariff assumptions suggest that with the increased yields, a tariff level of 5 percent would eliminate imports and that tariffs above this level would bring no benefits. This reflects the fact that the increased yields from technical progress would result in the increase in production to fully satisfy domestic demand and hence there would be no demand for imports. This finding has implications for the government's short and medium strategic policy focus. While increasing the tariff in the short term may be beneficial, over the medium term the focus should be on raising productivity in the rice sector. This is likely to have a much larger impact on boosting consumer/producer surplus, through simultaneously lowering price to consumers and raising the income of producers.

Table 15: Results of Technical Simulation

Tariff level (%)	0	1	5	10	15
Key policy indicators					
20. CPS (US$ Mn)	1,486.0	1,462.8	1,462.8	1,462.8	1,462.8
21. Employment (No.)	377,600	792,770	792,770	792,770	792,770
22. Production (Mt)	974,833.7	1,509,816.0	1,509,816.0	1,509,816.0	1,509,816.0
23. Exports (Mt)	512,430.0	512,430.0	512,430.0	512,430.0	512,430.0
24. Imports (Mt)	550,710.0	115,736.8	-	-	-
25. Trade balance (Mn$)	(156.40)	207.02	207.02	207.02	207.02
26. Fiscal Revenues ($)	-	154,300	-	-	-
27. Price ($/Mt)	594.20	635.03	635.0	635.0	635.0
28. Price increase (%)		6.9	0.0	0.0	0.0

Source: Model Simulation

VI. Summary, Conclusion and Policy Implications

Rice is a staple in Sierra Leone with an annual per capita consumption of 104kg—among the highest in the Sub-Saharan Africa region. Sierra Leone has ideal agroclimatic conditions for growing rice, including abundant rainfall, naturally fertile soils, sunlight and river basins; and nearly three-quarters of the country's 5.4 million hectares is suitable for rice production. Sierra Leone has a natural comparative advantage in the production of rice and up until the mid-1950s it had been a net exporter of rice. However, except for a few instances in the immediate post-independence period, the country has not been able to achieve sustained self-sufficiency in rice production and consequently has spent an average of US$108.6 million on rice importation over the past 10 years.

The past efforts to reestablish sustained self-sufficiency in the rice sector have been mostly disappointing. Sierra Leone's agricultural development policy has, since independence, focused on the achievement of self-sufficiency in rice, among other objectives, with most of the government support targeting smallholders but with minimal results. Questions have been raised about the impact of the waiver of the ECOWAS tariff on imported rice. These are key questions that have partly motivated this paper. The challenge is regarding what balance should be struck between the positive effects on consumer welfare of the lower price consequent on the waiver versus the adverse effects on producer welfare of the lower price, which mutes the supply response. The policy issue is complicated by the fact that some producers are also consumers when own-production falls short of household demand particularly during the "hunger season."[16]

The analysis in this study makes use of a programming model designed to produce a consistent quantitative framework for the Sierra Leone rice sector in order to simulate the effects of policy interventions as well as the potential impact of technical progress in the sector. The model is largely based on survey information collected in 2016. Importantly, the model is disaggregated across the five rice ecologies, thereby providing a richer set of simulation results. Furthermore, since the model includes both household as well as hired-in or temporary labor, some sense of the distributional impact of different trade or labor policy can be gleaned from the simulations.

Simulation of the base year as a basic validation test showed that the sector model performed well with only minor deviations between the survey data and the simulated results, with the exception of employment, where the simulated level of employment was lower than for the survey. This finding suggests that the sector is not optimal in the use of labor and is entirely consistent with the narrative of high levels of unemployment and underemployment in Sierra Leone. Over the 10-year period between 2009 and 2018 the unemployment rate in Sierra Leone has averaged 8.25 percent per year.[17]

The simulation of the base year also suggests that Sierra Leone's rice sector is operating at a sub-optimal level in the use of one critical resource—land. The use of two of the most productive ecologies—Mangrove Swamp and Riverain are well below their availabilities. The sub-optimal use of these two ecologies is reflected in the shadow prices. The shadow prices for a hectare of Mangrove Swamp and Riverain are $615.76 and $107.89, respectively. This means that bringing an additional hectare of the former ecology into production would increase producer/consumer surplus by $615.76 and an additional hectare of

[16] The 'hunger season' runs usually from May to December, when local production is unable to meet domestic demand and import of rice is needed to fill the gap.
[17] World Bank, World Development Indicators.

Riverain land would increase producer/consumer surplus by $107.89. At the same time, the shadow price of -$211.80 for the Upland ecology suggests that each additional hectare put into production reduces producer/consumer surplus by $211.80. These findings call for a major land use policy shift, including increased government investment in the Mangrove Swamp and Riverain to provide basic infrastructure, services and the incentives to crowd-in private sector investments in these two ecologies.

Simulation of the impact of a tariff suggest that, overall, Sierra Leone would benefit from the imposition of a moderate level of tariff, up to say 10 percent—in line with the ECOWAS Common External Tariff (CET) rate. Although consumer surplus would fall, as a result of the higher price, with the largest impact being with the move from zero tariff to a 1 percent rate, the increase in employment due to the supply response in the rice sector would be a more important longer-term policy goal. However, increasing the tariff beyond 10 percent would have no positive impact on the supply response, employment or indeed fiscal revenues since imports would be completely replaced by domestic production. The expected positive supply response to the higher price for rice on account of the imposition of the tariff may be fairly rapid given that rice is a short duration crop (3-6 months). However, the supply response could be constrained by other structural factors, including the availability of good quality seeds, fertilizer and effective extension services to provide farmers with advice on good husbandry practices.

The impact of an increase in the minimum wage is simulated in the context of different levels of tariffs. The results suggest that increasing the minimum wage under the current a zero-tariff regime will have very little impact on employment in the rice sector, in large part because much of the labor is from farm-owning households and there are no temporary workers hired in. However, a 10 percent increase in the minimum wage under a 10 percent tariff regime, would result in a substantial reduction in total employment in the rice sector. Furthermore, the impact of unemployment would be much larger for temporary laborers, who are likely to be landless and poor. Keeping inflation low, through effective fiscal and monetary policies may therefore be a better option to tame inflation than raising the minimum wage to compensate for high inflation. The higher wage should come from increased productivity within the sector, including through the use of quality inputs, including seeds and the adoption of appropriate, modern cultural practices.

The simulation of a technical experiment based on actual field trials suggests that both producer and consumer welfare could be improved through increased yields as a result of improved practices. Increased yields would also provide the government with more policy options in the use of tariffs. For example, with increased yields (in the order of 30 -75 percent), a 5 percent tariff would eliminate imports through the domestic supply response. However, attaining and sustaining higher yields, even for improved varieties, requires consistent application of good agricultural practices – and given the weak agricultural extension system, this is a major challenge.

In summary, the simulation from the rice sector model suggests that Sierra Leone's rice sector is operating at a sub-optimal level. Moving to a more optimal path will require structural policies and incentives to shift production from low-yield ecologies to high-yield ecologies. In addition, the more optimal policy path for the government to balance consumer and producer welfare and meet its objective of creating jobs is to employ a moderate level of tariff (no greater than 10 percent) combined with policies to improve the productivity of the sector. Such policies could include (i) improving access to quality inputs for the sector, through fostering markets that include private sector players; (ii) enhancing the quality of extension services to encourage the adoption of improved cultural practices in the sector; and (iii) employing macroeconomic policies that avoid wage inflation that could hurt jobs for temporary labor in the sector. Without such concerted policy actions there is little hope that Sierra Leone's rice sector could rise to its potential and help to lift some 800,000 people out of poverty.

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Annex Table 1: Proof of land ownership

Instrument	Freetown	Other urban	Rural	Overall
No document	15.8	65.0	61.2	61.3
Land title	41.7	22.0	32.0	31.3
Traditional certificate	4.9	10.9	6.1	6.5
Proof of sale	23.1	1.3	0.2	0.4
Other documents	14.6	0.8	0.5	0.6
Total	100	100	100	100

Source: 2014 Sierra Leone Labor Force Survey

Annex Table 2: Educational achievement among self-employed agricultural workers

Educational level	Men	Women	Overall
Never went to school	72.8	96.1	80.0
Incomplete primary	6.0	4.6	5.2
Complete primary	9.1	5.6	7.2
Completed lower secondary	7.0	3.5	5.1
Completed upper secondary	4.5	0.2	2.2
Technical degree/certificate	0.7	0.0	0.3
Tertiary degree	0.0	0.0	0.0
Total	100	100	100

Source: 2014 Sierra Leone Labor Force Survey